GDL 90
Data Interface Specification

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GARMIN™

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HISTORY OF REVISIONS

Part No.	Revision	Date	Description
560-1058-00	--	8/23/04	Initial Release.
560-1058-00	A	6/04/2007	Update for GDL 90 Version 2.1 & 2.2 application software.

ORDERING INFORMATION

To receive additional copies of this publication, order part # **560-1058-00 Rev A,** *GDL 90 Data Interface Specification*.

OTHER PUBLICATIONS

RTCA/DO-282A	UAT MOPS
RTCA/DO-267A	FIS-B MASPS
RTCA/DO-286	TIS-B MASPS
Garmin P/N 560-1049-xx	GDL 90 Installation Manual

1. Introduction

1.1. PURPOSE

The purpose of this document is to define the data interface to the serial communication and control panel ports of the Garmin AT UAT Data Link Sensor, model GDL 90 (P/N 430-6081-1xx-xxx). The GDL 90 complies with the requirements of this document when configured for the “Traffic Alert” and "Pass-through" interfaces (see §1.3 for a summary of these interfaces).

1.2. SCOPE

This document describes the format of the serial data sent to and received by the GDL 90. Not all serial messages defined will necessarily be supported in any given installation of the GDL 90. Some configurations only have a subset of these messages. See the GDL 90 Installation Manual for the configuration options.

The control panel interface is included in this document. Information on altitude sources can be found in the GDL 90 Installation Manual.

For the purposes of this document, the device to which the GDL 90 is attached is assumed to be a multi-function display, and is referred to here as “the Display” or “MFD” interchangeably.

Certain features described in this document apply only to specific GDL 90 software versions. GDL 90 units are marked on the configuration label with SW Mod Level. Features that apply to certain version of GDL 90 are identified by the text “**SW Mod x**”, where ‘**x**’ is replaced with the appropriate level. Unless otherwise stated, the specifications apply to **SW Mod B** only.

Summary of SW Mod Levels:

SW Mod B = Ver 2.0 (supports the Public IC)

SW Mod C = Ver 2.1 (adds Ownship Geometric Altitude, additional status bits)

SW Mod D = Ver 2.2. (converts TIS-B call sign ‘dash’ to ‘space’ for less display clutter)

1.3. INTERFACE TYPES

This specification describes two types of interfaces to the Display. The type of interface being used is specified by the GDL 90 installation configuration.

The first is the “Traffic Alert” interface. When enabled by the GDL 90 configuration, this interface provides conflict alerts for proximate traffic that are projected to enter the protected zone surrounding the ownship position.

The second interface is the “Pass-through” interface. This interface does not provide conflict alerts. The output reports under this interface consist of the message payloads that are received over the UAT data link, without modification. Due to constraints on the interface bandwidth, received UAT messages are filtered by range from ownship.

See Table 2 for a listing of which Messages the GDL 90 uses for each of these interface types.

1.4. DISCLAIMER FOR DISPLAY VENDORS

Manufacturers of display devices that use the information contained in this document for interface to the GDL 90 UAT transceiver are required to ensure that their display devices show the following message every time such display device is turned on or activated. This message may not be altered, changed, or abbreviated.

> Traffic and weather information displayed is advisory only; it is the pilot's responsibility to see and avoid traffic and to determine the weather conditions. You assume total responsibility and risk associated with using all such information. You agree with and accept the content of this disclaimer by using this equipment.

1.5. DISCLAIMER; NO WARRANTY; LIMITATION OF LIABILITY

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1.6. GLOSSARY

ADS-B : Automatic Dependant Surveillance - Broadcast

CSA : Conflict Situational Awareness.

FIS-B : Flight Information System - Broadcast

MASPS : Minimum Aviation System Performance Specifications

MOPS : Minimum Operational Performance Specifications

TIS-B : Traffic Information System - Broadcast

UAT : Universal Access Transceiver

2. RS-422 Bus Message Structure

2.1. Physical Interface

The GDL 90 supports a bi-directional asynchronous communication interface using RS-422 signaling. The communication port is configured for the following characteristics:

Baud Rate: 38,400 (nominal)
Start Bits: 1
Data length: 8 bits
Stop Bits: 1
Parity: None
Flow Control: None

Electrically, RS-422 uses a differential signal pair driven from a single +5.0 volt supply. The two signals of the pair are referred to as ‘A’ and ‘B’. The Mark (or ONE) condition is indicated by the ‘A’ signal being at a higher voltage than the ‘B’ signal.

Bit and Byte order:

By convention, asynchronous serial communication transmits byte-wise data over the interface with the least-significant bit first, immediately following the Start bit. The most significant bit is followed by the Stop bit.

In this document, the least significant bit of a byte is referred to as Bit 0, carries a weight of $1_{(decimal)}$, and is depicted as the right-most bit. The most-significant bit of a byte is referred to as Bit 7, carries a weight of $128_{(decimal)}$, and is depicted as the left-most bit.

In this document, use of hexadecimal notation is indicated by preceding the data with the characters "0x--". The leftmost character represents the 4 most significant bits.

Electrical Connections:

The electrical connections to the GDL 90 RS-422 port are shown in Table 1.

Table 1 - Interface Connections

Signal Name	Direction	Connector Pin
Tx-A	Out of GDL 90	J2 - Pin 11
Tx-B	Out of GDL 90	J2 - Pin 29
Rx-A	Into GDL 90	J2 - Pin 10
Rx-B	Into GDL 90	J2 - Pin 28

2.2. MESSAGE STRUCTURE OVERVIEW

The datalink message structure is based on "Async HDLC", as described in RTCA/DO-267 (Section 3.4.3.2). Certain modifications have been made where appropriate for the intended application. Since the UAT datalink is intended for broadcast services only, an avionics datalink interface need support only a datagram service, with no provisions for addressed or connected modes of communication. These modifications serve to optimize the avionics data interface for simplicity and data flow efficiency.

2.2.1. Datalink Structure and Processing

The basic message structure is as follows (see Figure 1):

1) A Flag Byte character (0x7E).
2) A one-byte Message ID which specifies the type of message being transmitted.
3) The Message Data, which can be of variable lengths.
4) A message Frame Check Sequence (FCS). The FCS is a 16-bit CRC with the least significant byte first.
5) Another Flag Byte character (0x7E).

Figure 1 - Message Structure

Flag Byte	Message ID (Byte 1)	Message Data (Bytes 2 through N)	Frame Check Sequence (2 bytes - LSB first)	Flag Byte

Binary transparency is provided by use of the "byte-stuffing" technique. To include a data byte that coincides with either a Flag Byte (0x7E) or Control-Escape character (0x7D) within a message, each is converted into a unique two-byte sequence.

To prepare a message for transmission, wherever a 0x7D or 0x7E byte is found in between the two Flag Bytes, a Control-Escape character is inserted, followed by the original byte XOR'ed with the value 0x20. Using this method, the Control-Escape and Flag Byte characters only appear in a message for framing or byte-stuffing purposes.

On reception, any Control-Escape characters found are discarded, and the following byte is included in the message after being converted to its original form by XOR'ing with the value 0x20.

For example:

start of message ID #2 with second byte 0x7E: "`0x7E 0x02 0x7D 0x5E …`"
start of message ID #3 with second byte 0x7D: "`0x7E 0x03 0x7D 0x5D …`"
end of message with CRC value of 0x7D 0x7E: "`…0x7D 0x5D 0x7D 0x5E 0x7E`"

Note that on transmit, the FCS must be calculated on the message data prior to the byte-stuffing process. Similarly, on reception the byte-stuffing must be removed prior to checking the FCS.

The steps to construct a message for transmission are as follows:

1) Assemble the message with the Message ID byte included.
2) Calculate the FCS and append it to the end of the message (least significant byte first).

3) Find all of the Control-Escape and Flag Byte characters in the message and make the conversion.
4) Frame the message by adding Flag Byte characters to the beginning and the end of the message.

If two messages are being sent back-to-back, it is necessary to have two Flag Bytes in a row. Several messages sent in sequence should appear as:

```
"0x7E <message1> 0x7E 0x7E <message2> 0x7E … 0x7E <messageN> 0x7E"
```

The steps for message reception are as follows:

1) Look for a Flag Byte character.
2) Save all characters until another Flag Byte character is received.
3) Look for all Control-Escape characters in the saved string. Discard each one found, and XOR the following character with 0x20. The resulting character should equal either 0x7D or 0x7E.
4) Calculate the FCS on the clear message– not including the Start Flag, End Flag, or the FCS itself. The calculated FCS should match the FCS characters in the message. If not, discard the message.
5) The message has been authenticated and is ready for use.

2.2.2. Message ID

In order to provision for future inclusion of a data link address field, the Message ID is represented by the 7 least-significant bits of the byte immediately following the initial Flag byte. In equipment that complies with this version of this interface document, the most significant bit of the Message ID will always be ZERO, so that the Message ID can be treated as an 8-bit value with a range of 0-127 (decimal). Any messages that have a Message ID outside of this range should be discarded.

Within this document, Message IDs are stated in decimal notation.

2.2.3. FCS Calculation

The FCS used in this interface is a CRC-CCITT. For processing efficiency, a table-generated CRC calculation can be used. This table contains 256 elements. The table should be calculated at startup and left unchanged afterward. The following C code shows one method the table can be constructed. “Crc16Table” is an unsigned 16-bit integer array of 256 elements. An “int” is a 16-bit integer. A “long int” is a 32-bit integer.

```
void crcInit( void )
{
    unsigned int i, bitctr, crc;
    for (i = 0; i < 256; i++)
    {
        crc = (i << 8);
        for (bitctr = 0; bitctr < 8; bitctr++)
        {
            crc = (crc << 1) ^ ((crc & 0x8000) ? 0x1021 : 0);
        }
        Crc16Table[i] = crc;
    }
}
```

The actual calculation of the CRC can be accomplished using the following function.

```
unsigned int crcCompute(        // Return – CRC of the block
    unsigned char *block,       // i – Starting address of message
    unsigned long int length,   // i – Length of message
    )
{
    unsigned long int i;
    unsigned int crc = 0;

    for (i = 0; i < length; i++)
    {
        crc = Crc16Table[crc >> 8] ^ (crc << 8) ^ block[i];
    }

    return crc;
}
```

2.2.4. Message Example

The byte sequence [0x7E 0x00 0x81 0x41 0xDB 0xD0 0x08 0x02 0xB3 0x8B 0x7E] represents a Heartbeat message including the Flags and the CRC value.

2.3. BANDWIDTH MANAGEMENT

The GDL 90 implements a method of managing the use of the data interface bandwidth. This is necessary because the UAT data link is capable of more throughput than the interface to the Display can provide. The bandwidth management method is described below:

The GDL 90 application software limits the use of the data interface to 90% of the maximum capacity. For example, with 38400 baud, and 10 bauds per byte (1 start + 8 data + 1 stop), this gives 3,840 bytes per second. Ninety percent of this value is approximately 3,500 bytes per second.

The 10% margin allows for some excess capacity for the byte-stuffing provisions of the datalink interface, and acquisition of new target tracks.

Within this 90% limit, the GDL 90 will output the following messages:

- one Heartbeat message per second,
- followed by the Ownship report,
- followed by any Traffic Alert reports (if enabled),
- followed by a number of Uplink messages (configurable, maximum of 0 to 4 per second),
- followed by proximate Traffic reports,
- followed by additional Uplink messages (if extra bandwidth capacity is available).

The proximate Traffic reports are prioritized on the interface by range proximity to the ownship position. Proximate Traffic reports can be either for non-alert targets when the “Traffic Alert” interface is in use, or are normal targets when the “Pass-through” interface is in use.

The Uplink messages that are output first are those received from the most proximate ground stations. If more than one Uplink message is received from the same ground station, priority is given to the messages received in the earliest time slots. Since the ground stations rotate their time slot usage every second, all co-located time slots are given equal service.

Note that only Uplink messages marked in the UAT Specific Header (see §4.1.1) as containing valid application data are eligible to be output.

Certain parameters of the Bandwidth Management method (e.g. the number of Uplinks per second) can be customized for a given installation through the GDL 90 configuration process.

3. Message Definitions

There are several different types of messages that may be passed on the data interface. The following tables describe the possible message formats. The sections that follow give definitions of the report contents, and recommendations for the use of these messages by the Display.

In general, multi-byte fields are transmitted most-significant byte first, unless otherwise stated.

Table 2 presents a summary of the messages defined in this section, and for which interface types the messages are supported. The Message ID is used as defined in Section 2.2.1. The GDL 90 is configured at installation for which type of interface is in use.

Table 2 - Message Summary

Message ID & Name	I/O	Traffic Alert Interface	Pass-Through Interface	Section Reference
0_{10} - Heartbeat	Out	Yes	Yes	§3.1
2_{10} - Initialization	In	Yes	Yes	§3.2
7_{10} - Uplink Data	Out	Yes	Yes	§3.3
9_{10} - Height Above Terrain	In	Yes	*(see note)*	§3.7
10_{10} - Ownship Report	Out	Yes	Yes	§3.4
11_{10} - Ownship Geometric Altitude	Out	Yes	Yes	§3.8
20_{10} - Traffic Report	Out	Yes	-	§3.5
30_{10} - Basic Report	Out	-	Yes	§3.6
31_{10} - Long Report	Out	-	Yes	§3.6

Note: The Height Above Terrain message is not used with the Pass-through interface.

The message directions "In" and "Out" are with respect to the GDL 90. The following sections define and discuss each message in detail.

3.1. HEARTBEAT MESSAGE

The GDL 90 outputs a Heartbeat message at the beginning of each UTC second. The message format is given in Table 3, and discussed further in the remainder of this section.

Table 3 - Heartbeat Message (Output)

Byte #	Name	Size	Value
1	Message ID	1	0_{10} = Heartbeat
2	Status Byte 1 Bit 7: GPS Pos Valid Bit 6: Maint Req'd Bit 5: IDENT Bit 4: Addr Type Bit 3: GPS Batt Low Bit 2: RATCS Bit 1: reserved Bit 0: UAT Initialized	1	 1 = Position is available for ADS-B Tx 1 = GDL 90 Maintenance Req'd 1 = IDENT talkback 1 = Address Type talkback 1 = GPS Battery low voltage 1 = ATC Services talkback - 1 = GDL 90 is initialized
3	Status Byte 2 Bit 7: Time Stamp (MS bit) Bit 6: CSA Requested Bit 5: CSA Not Available Bit 4: reserved Bit 3: reserved Bit 2: reserved Bit 1: reserved Bit 0: UTC OK	1	 - Seconds since 0000Z, bit 16 1 = CSA has been requested 1 = CSA is not available at this time - - - - 1 = UTC timing is valid
4-5	Time Stamp	2	Seconds since 0000Z, bits 15-0 (LS byte first)
6-7	Message Counts	2	See §3.1.4
	Total Length	7	

The Heartbeat message provides real-time indications to the Display of the status and operation of the GDL 90. The Heartbeat message is sent once per second in response to the UTC timing reference signal. The Time Stamp field provides the absolute time reference in integer seconds for the Traffic reports that follow it during the remainder of this second.

Each of the fields is described below:

3.1.1. Status Byte 1

a) Bit 7: GPS Position Valid: This bit is set to ONE by the GDL 90 when it has a valid position fix that is being included in its transmitted ADS-B messages. <u>MFD Recommendation</u>: Annunciate to the flight crew when this bit is ZERO, since it indicates that no valid ownship data is being transmitted to other participants.

b) Bit 6: Maintenance Required: This bit is set to ONE when the GDL 90 has detected a problem that requires maintenance. MFD Recommendation: Post a message to the flight crew when this bit is ONE, to indicate that maintenance is required.

c) Bit 5: IDENT talkback: This bit is set to ONE when the GDL 90 has set the IDENT indication in its transmitted ADS-B messages. This provides feedback to the display when the IDENT function has been activated from the control source.

d) Bit 4: **SW Mod C:** Address Type: This talkback bit is set to ONE to indicate that the GDL 90 is transmitting ADS-B messages using a temporary self-assigned ("anonymous") address. This provides feedback to the display regarding which type of ownship identity is being transmitted.

   If SW Mod C is not installed, this bit is undefined and is always set to ZERO.

e) Bit 3: GPS Battery Low: This bit is set to ONE to indicate that the GDL 90 needs maintenance to replace its internal GPS battery. The GDL 90 continues to be capable of normal operation, except that the time for initial GPS acquisition will be much longer than normal.

f) Bit 2: **SW Mod C:** RATCS: This talkback bit is set to the present state of the Receiving ATC Services indication in the transmitted ADS-B messages. This provides feedback to the display regarding whether the RATCS feature is enabled and operating.

   If SW Mod C is not installed, this bit is undefined and is always set to ZERO.

g) Bit 1: Reserved: This bit is set to ZERO in equipment that complies with this version of the specification.

h) Bit 0: UAT Initialized: This bit is set to ONE in all Heartbeat messages.

3.1.2. Status Byte 2

a) Bit 7: UAT Time Stamp - Bit 16: This is the Most Significant Bit of the UAT Time Stamp, in seconds elapsed since UTC midnight (0000Z).

b) Bit 6: CSA Requested: When set to ONE, this bit acknowledges to the Display that the GDL 90 Conflict Situational Awareness (CSA) algorithm has been requested. See §3.2.2 for reference.

c) Bit 5: CSA Not Available: When set to ONE, this bit indicates to the Display that the CSA algorithm has been requested but is not available.

MFD Recommendation: Annunciate changes in the CSA operational status to the flight crew, including but not limited to the case where CSA has been requested but is not available.

d) Bit 4..1: Reserved: These bits are set to ZERO in equipment that complies with this version of the specification.

e) Bit 0: UTC OK: This bit is set to ONE when the GDL 90 is using a valid UTC timing reference.

3.1.3. UAT Time Stamp

The Heartbeat message includes the current time-of-day in whole seconds elapsed since UTC midnight (0000Z). This requires a 17-bit data field. The most significant bit (bit 16) is in Status Byte 2 bit 7. The remaining 16 bits are conveyed least significant byte first, using the two Time Stamp bytes.

3.1.4. Received Message Counts

Two bytes are used to report the number of UAT messages received by the GDL 90 during the previous second. The count fields are formatted as follows:

a) Uplink receptions: Bits 7..3 of the first Message Count byte contain the count of Uplink Messages received. Bit 7 is the most significant bit.

b) Reserved: Bit 2 of the first Message Count byte is reserved, and is set to ZERO.

c) Basic and Long receptions: The total number of Basic and Long messages together is contained in a 10-bit field. The two most significant bits are in Bit 1..0 of the first Message Count byte, and the eight least significant bits are contained in the second Message Count byte. The counter value will hold at the maximum value if the number of received messages exceeds 1,023.

These counters represent all of the UAT messages that have been successfully received and validated, regardless of whether they result in an output report on the GDL 90 interfaces.

Example:

If 4 Uplink messages and a total of 567 Basic and Long messages were received in the previous second, the Heartbeat message Byte 6 value will be 0x22, and the Byte 7 value will be 0x37.

3.2. INITIALIZATION MESSAGE

The Init message is sent by the Display once per second, and is described in Table 4.

Table 4 - Initialization Message (Input)

Byte #	Name	Size	Value
1	Message ID	1	2_{10} = Initialization
2	Configuration Byte 1 Bit 7: reserved Bit 6: Audio Test Bit 5: reserved Bit 4: reserved Bit 3: reserved Bit 2: reserved Bit 1: Audio Inhibit Bit 0: CDTI OK	1	 - 1 = Initiate audio test - - - - 1 = Suppress GDL 90 audio output 1 = CDTI capability is operating
3	Configuration Byte 2 Bit 7: reserved Bit 6: reserved Bit 5: reserved Bit 4: reserved Bit 3: reserved Bit 2: reserved Bit 1: CSA Audio Disable Bit 0: CSA Disable	1	 - - - - - - 1 = Disable GDL 90 audible traffic alerts 1 = Disable CSA traffic alerting
	Total Length	3	

The Init message provides the GDL 90 with various control signals.

3.2.1. Configuration Byte 1

Configuration Byte 1 provides the following control signals.

a) Bits 7, 5, 4, 3, 2: These bits are reserved for future use, and should be set to ZERO by the Display.

b) Bit 6: Audio Test: This bit is set to ONE to invoke the “PlayAudio” test as described in the GDL 90 Installation Manual.

c) Bit 1: Audio Inhibit: This bit is set to ONE when the GDL 90 audio output is inhibited. This function is similar to the Audio Inhibit discrete input (see the GDL 90 Installation Manual).

d) Bit 0: CDTI OK: This bit is set to ONE by the Display when a cockpit traffic display (CDTI) function is available. This bit is included in the GDL 90 transmitted ADS-B messages, for use by other participants as appropriate.

3.2.2. Configuration Byte 2

Configuration Byte 2 provides control of the GDL 90 traffic alerting functions.

a) Bits 7..2: These bits are reserved for future use, and should be set to ZERO by the Display.

b) Bit 1: CSA Audio Disable: This bit is set to ONE by the Display when the flight crew elects to suppress the audio traffic alerts generated by the CSA algorithm.

c) Bit 0: CSA Disable: This bit is set to ONE by the Display when the flight crew elects to turn off the generation of all traffic alerts by the CSA algorithm.

3.3. UPLINK DATA MESSAGE

Uplink messages received from UAT Ground Broadcast Transceivers are reported to the Display using the Uplink Data message, as described in Table 5.

Table 5 - Uplink Data Message (Output)

Byte #	Name	Size	Value
1	Message ID	1	7_{10} = Uplink Data
2-4	Time of Reception	3	24-bit binary fraction Resolution = 80 nsec
5-436	Uplink Payload	432	See §3.3.2
	Total Length	436	

The Uplink message provides the Display with the Time of Reception value, followed by the entire contents of the Uplink message received over the air.

Note that the Uplink message must be marked as containing valid Application Data in order to be output to the Display by the GDL 90. Refer to §4.1.1 "UAT-Specific Header" for more information.

3.3.1. Time of Reception (TOR)

The TOR is a 24-bit value, with a resolution of 80 nanoseconds. The valid range is 0 to 1 second (values 0_{10} through $12{,}499{,}999_{10}$). The TOR is conveyed as three bytes, with the least significant byte transmitted first.

A TOR of "all ONES" (0xFFFFFF, or $16{,}777{,}215_{10}$) indicates that the TOR value is not valid (i.e. the ownship GDL 90 does not have sufficient timing accuracy to output a useful time value).

The complete Time of Applicability of a message is determined by combining the Time Stamp from the Heartbeat message (which gives the integer seconds since UTC midnight), with the seconds fraction found in the TOR field of the report.

3.3.2. Uplink Payload

The Uplink Data consists of the entire contents of the Uplink message received over the air. As defined by RTCA/DO-282, the Uplink message consists of the UAT-Specific Header (8 bytes), followed by 424 bytes of generic binary data. See §4 "Uplink Payload Format" for further specifications of the Uplink Payload field contents.

3.4. OWNSHIP REPORT MESSAGE

The GDL 90 will always output an Ownship Report message once per second. The message uses the same format as the Traffic Report, with the Message ID set to the value 10 (See Table 6). See §3.5.1 for specification of the Traffic Report field.

Table 6 - Ownship Report Message (Output)

Byte #	Name	Size	Value
1	Message ID	1	10_{10} = Ownship Report
2 - 28	Ownship Report	27	See §3.5.1
	Total Length	28	

The Ownship Report is output by the GDL 90 regardless of whether a valid GPS position fix is available. If the ownship GPS position fix is invalid, the Latitude, Longitude, and NIC fields in the Ownship Report all have the ZERO value.

Ownship geometric altitude is provided in a separate message (**SW Mod C**).

3.5. TRAFFIC REPORT

When the Traffic Alert interface is in use, a Traffic Report message is output from the GDL 90 in each second for each alerted or proximate target. The Traffic Report message is defined in Table 7. Reports are output for at least 32 targets, up to the maximum number that the interface can support (depending on the baud rate and the Uplink configuration).

Table 7 - Traffic Report Message (Output)

Byte #	Name	Size	Value
1	Message ID	1	20_{10} = Traffic Report
2 - 28	Traffic Report	27	See §3.5.1
	Total Length	28	

All Traffic Reports output from the GDL 90 have a Time of Applicability of the beginning of the current second. Therefore, there is no explicit Time of Reception field in the Traffic Report. The Time Stamp conveyed in the most recent Heartbeat message is the Time of Applicability for all Traffic Reports output in that second.

A Traffic Report is generated for each tracked target every second, as long as the target is identified by CSA as a priority target. If no ADS-B message is received for a tracked target, an extrapolated report is generated for that target. Each target is extrapolated until its track is discontinued by CSA.

3.5.1. Traffic and Ownship Report Data Format

The Traffic Report data consists of 27 bytes of binary data as shown in Figure 2. Each field that makes up the report is a multiple of 4 bits. Each lower case character represents a 4-bit value. Each pair of lower-case characters represents a single byte value.

For example, Byte 2 of this message is the first byte of the Traffic Report data, and contains the value "0xst", where "s" represents the Traffic Alert Status and occupies Byte 2 bits 7..4, and 't' represents the Address Type and occupies Byte 2 bits 3..0. Similarly, Byte 28 contains the value "0xpx".

Figure 2 - Traffic Report data

Traffic Report data = st aa aa aa ll ll ll nn nn nn dd dm ia hh hv vv tt ee cc cc cc cc cc cc cc cc px

Table 8 defines the Traffic Report fields. In the descriptions that follow, all fields are encoded with the most significant digit first unless otherwise noted. See §3.5.2 for an example that illustrates the byte packing and ordering.

Table 8 - Traffic Report Fields

Field	Definition
s	Traffic Alert Status. s = 1 indicates that a Traffic Alert is active for this target.
t	Address Type: Describes the type of address conveyed in the Participant Address field:
aa aa aa	Participant Address (24 bits).
ll ll ll	Latitude: 24-bit signed binary fraction. Resolution = 180 / 2^{23} degrees.
nn nn nn	Longitude: 24-bit signed binary fraction. Resolution = 180 / 2^{23} degrees.
ddd	Altitude: 12-bit offset integer. Resolution = 25 feet. Altitude (ft) = ("ddd" * 25) - 1,000
m	Miscellaneous indicators: (see text)
i	Navigation Integrity Category (NIC):
a	Navigation Accuracy Category for Position (NACp):
hhh	Horizontal velocity. Resolution = 1 kt.
vvv	Vertical Velocity: Signed integer in units of 64 fpm.
tt	Track/Heading: 8-bit angular weighted binary. Resolution = 360/256 degrees. 0 = North, 128 = South. See Miscellaneous field for Track/Heading indication.
ee	Emitter Category
cc cc cc cc cc cc cc cc	Call Sign: 8 ASCII characters, '0' through '9' and 'A' through 'Z'.
p	Emergency/Priority Code:
x	Spare (reserved for future use)

3.5.1.1 Traffic Alert Status

This is a 4-bit field "s" which indicates whether CSA has identified this target with an alert. The following values for this field are defined:

s = 0 : No alert
s = 1 : Traffic Alert
s = 2 through 15 : reserved

MFD Recommendation: The Display should depict targets for which a Traffic Alert exists using a flashing yellow traffic symbol.

Traffic Annunciation: An increase in the number of targets that are in the Traffic Alert status should cause an audible annunciation.

3.5.1.2 TARGET IDENTITY

The identity of a target is formed by the combination of the Address Type "t" along with the Participant Address "aaaaaa". Together these form a 28-bit field that uniquely identifies a given ADS-B or TIS-B participant. The Address Types are defined as follows:

t = 0 : ADS-B with ICAO address
t = 1 : ADS-B with Self-assigned address
t = 2 : TIS-B with ICAO address
t = 3 : TIS-B with track file ID.
t = 4 : Surface Vehicle
t = 5 : Ground Station Beacon
t = 6-15 : reserved

MFD Recommendation: The Display should determine the appropriate style of traffic symbol for a target by using a combination of Address Type, Emitter Category, NIC value, Air/Ground state, and Traffic Alert status.

MFD Recommendation: The uniqueness of the Target Identity depends primarily on the equipment installer configuring the ADS-B equipment with the correct ICAO address. For TIS-B targets, uniqueness also depends on the ability of the ground-based TIS-B processor to fuse radar and ADS-B reports into track file IDs accurately. Neither of these processes can be expected to always generate a unique identification. Therefore, Display vendors are advised to take appropriate measures to cope with the possibility that the Target Identity alone may not always be sufficient to uniquely identify duplicate targets. This caution includes the possibility of reception of an ownship "shadow" TIS-B target.

3.5.1.3 LATITUDE AND LONGITUDE

The "'llllll" and "nnnnnn"' values represent the Latitude and Longitude values in 24-bit "semicircle" 2-s compliment units. Latitude and Longitude are both encoded over a range of +/-180 degrees. This provides a resolution of approximately 2.14577 x 10^{-5} degrees (approximately 2.38 meters at the equator). The data is presented most significant bit first.

For Latitude, North is considered Positive. The maximum Latitude value is +90.0 degrees. The minimum Latitude value is -90.0 degrees.

For Longitude, East is considered Positive. The maximum Longitude value is +(180 minus LSB) degrees. The minimum Longitude value is -180.0 degrees.

A target with no valid position has Latitude, Longitude, and NIC all set to zero.

Examples:

00.000 N or E degrees	0x00 00 00
00.000 + LSB N or E degrees	0x00 00 01
00.000 - LSB S or W degrees	0xFF FF FF
45.000 N or E degrees	0x20 00 00
45.000 S or W degrees	0xE0 00 00
90.000 E or N	0x40 00 00
-180.000 degrees	0x80 00 00
Max Longitude (+180 - LSB)	0x7F FF FF

3.5.1.4 ALTITUDE

The Altitude field "ddd" contains the pressure altitude (referenced to 29.92 inches Hg), encoded using 25-foot resolution, offset by 1,000 feet. The 0xFFF value represents that the pressure altitude is invalid. The minimum altitude that can be represented is -1,000 feet. The maximum valid altitude is +101,350 feet.

Examples:

-1,000 feet	0x000
0 feet	0x028
+1000 feet	0x050
+101,350 feet	0xFFE
Invalid or unavailable	0xFFF

MFD Recommendation: An invalid altitude should be depicted on the Display as the altitude field being dashed-out. The target altitude should support display of the target altitude as either absolute altitude, or altitude relative to the ownship.

3.5.1.5 MISCELLANEOUS INDICATORS

This 4-bit field "m" presents the following indicator bits that apply to the Traffic Report. See Table 9. Bits 1 and 0 describe the type of data conveyed in the "tt" field. Bit 2 describes whether the report is updated from an ADS-B message reception, or is extrapolated from a previous report. Bit 3 gives the Air/Ground state of the traffic.

Table 9 - Miscellaneous Field

Bit 3	Bit 2	Bit 1	Bit 0	Meaning
-	-	0	0	"tt" not valid
-	-	0	1	"tt" = True Track Angle
-	-	1	0	"tt" = Heading (Magnetic)
-	-	1	1	"tt" = Heading (True)
-	0	-	-	Report is updated
-	1	-	-	Report is extrapolated
0	-	-	-	On Ground
1	-	-	-	Airborne

3.5.1.6 INTEGRITY (NIC) AND ACCURACY (NACP)

The Integrity and Accuracy of the traffic is reported using a 4-bit value for each field. See Table 10. At the transmitting source, NIC is encoded by the Containment Radius (typically HPL). NACp is encoded using the Estimated Position Uncertainty (typically HFOM).

Table 10 - Integrity and Accuracy

Value ("i" or "a")	NIC (HPL)	NACp (HFOM)
0	Unknown	Unknown
1	< 20.0 NM	< 10.0 NM
2	< 8.0 NM	< 4.0 NM
3	< 4.0 NM	< 2.0 NM
4	< 2.0 NM	< 1.0 NM
5	< 1.0 NM	< 0.5 NM
6	< 0.6 NM	< 0.3 NM
7	< 0.2 NM	< 0.1 NM
8	< 0.1 NM	< 0.05 NM
9	HPL < 75 m and VPL < 112 m	HFOM < 30 m and VFOM < 45 m
10	HPL < 25 m and VPL < 37.5 m	HFOM < 10 m and VFOM < 15 m
11	HPL < 7.5 m and VPL < 11 m	HFOM < 3 m and VFOM < 4 m
12-15	Unused	Unused

Note: See DO-282A Table 2-15 and Table 2-45 for the full definition of the NIC and NACp values.

MFD Recommendation: Targets with either a NIC or NACp value that is 4 or lower (HPL >= 1.0 NM, or HFOM >= 0.5 NM) should be depicted using an icon that denotes a degraded target.

3.5.1.7 HORIZONTAL VELOCITY

Horizontal velocity "hhh" is encoded as a 12-bit unsigned value, in units of 1 knot. The direction of the velocity is given by the "tt" field (see §3.5.1.9). If the horizontal velocity is 4,094 knots or greater, the value will hold at the value 0xFFE.

Special Values: The value 0xFFF is reserved to convey that no horizontal velocity information is available.

3.5.1.8 VERTICAL VELOCITY

Vertical velocity "vvv" is encoded as a 12-bit signed value, in units of 64 feet per minute (FPM). The range that can be encoded is +/- 32,576 FPM. If the vertical velocity exceeds +/- 32,576 FPM the value will hold at the value that represents +/- 32,640 FPM.

Special Values: The value 0x800 is reserved to convey that no vertical velocity information is available. The values 0x1FF through 0x7FF and 0x801 through 0xE01 are not used.

Examples:

0 = 0 FPM
0x001 = 64 FPM climb
0xFFF = 64 FPM descend
0x1FD = 32,576 FPM climb
0x1FE = > 32,576 climb
0xE03 = 32,576 FPM descend
0xE02 = > 32.576 FPM descend
0x800 = no vertical rate available

3.5.1.9 TRACK/HEADING

The Track/Heading field "tt" provides an 8-bit angular weighted value. The resolution is in units of 360/256 degrees (approximately 1.4 degrees).

> *Note: Typically, all airborne targets report True Track. Targets on the ground can report either Track (if no heading sensor is present and the aircraft is in motion), or Heading (if equipped with a heading sensor).*

MFD Recommendation: The "tt" field provides the directionality of the traffic. When this field is Not Valid (see §3.5.1.5) the traffic should be depicted using a non-directional icon. Typically this would occur with a stationary aircraft that does not have a heading source.

3.5.1.10 Emitter Category

The "ee" field encodes the Emitter Category as a binary value within the range 0 to 39. Emitter categories are defined as shown in Table 11.

Table 11 - Emitter Categories

Value	Meaning	Value	Meaning
0	No aircraft type information	20	Cluster Obstacle
1	Light (ICAO) < 15 500 lbs	21	Line Obstacle
2	Small - 15 500 to 75 000 lbs	22	(reserved)
3	Large - 75 000 to 300 000 lbs	23	(reserved)
4	High Vortex Large (e.g., aircraft such as B757)	24	(reserved)
5	Heavy (ICAO) - > 300 000 lbs	25	(reserved)
6	Highly Maneuverable > 5G acceleration and high speed	26	(reserved)
7	Rotorcraft	27	(reserved)
8	(Unassigned)	28	(reserved)
9	Glider/sailplane	29	(reserved)
10	Lighter than air	30	(reserved)
11	Parachutist/sky diver	31	(reserved)
12	Ultra light/hang glider/paraglider	32	(reserved)
13	(Unassigned)	33	(reserved)
14	Unmanned aerial vehicle	34	(reserved)
15	Space/transatmospheric vehicle	35	(reserved)
16	(Unassigned)	36	(reserved)
17	Surface vehicle — emergency vehicle	37	(reserved)
18	Surface vehicle — service vehicle	38	(reserved)
19	Point Obstacle (includes tethered balloons)	39	(reserved)

MFD Recommendation: The Display should determine the appropriate style of traffic symbol for a target by using a combination of Address Type, Emitter Category, NIC value, Air/Ground state, and Traffic Alert status.

Example: "ee" = 0x11 -> Surface Emergency Vehicle.

3.5.1.11 Call Sign

The Call Sign is conveyed using 8 ASCII characters. The valid character values are the codes for the numbers '0' through '9', the letters 'A' through 'Z', and the Space character (0x20). Space is only used as a trailing pad character, or when no call sign character is available. With **SW Mod C** and earlier, the dash '-' character represents a printable code for a character that is unavailable. Starting with **SW Mod D**, the space character is used for unavailable characters, to reduce display clutter.

MFD Recommendation: The Call Sign field can contain any of the following types of information; an aircraft tail number (e.g. "N89TM"), an airline-style flight number (e.g. "UAL123"), or a company-specified identifier (e.g. "LFS32Y"). The Display may present the Call Sign to the flight crew to aid in visual acquisition. The Call Sign should not be relied on as a unique target identifier.

3.5.1.12 EMERGENCY/PRIORITY CODE

The Emergency Priority Code is a 4-bit value "p" that provides status information about the traffic. The values for "p" are given below:

p = 0 : no emergency
p = 1 : general emergency
p = 2 : medical emergency
p = 3 : minimum fuel
p = 4 : no communication
p = 5 : unlawful interference
p = 6 : downed aircraft
p = 7-15 : reserved

MFD Recommendation: Displaying the target Emergency/Priority Code may be useful in some specialized applications (e.g. Search and Rescue).

3.5.2. Traffic Report Example

This section presents a fully worked-out example of a typical Traffic Report, for a target airborne over Salem OR, stated in byte order including the Message ID.

Report Data:

No Traffic Alert
ICAO ADS-B Address (octal): 52642511_8
Latitude: 44.90708 (North)
Longitude: -122.99488 (West)
Altitude: 5,000 feet (pressure altitude)
Airborne with True Track
HPL = 20 meters, HFOM = 25 meters (NIC = 10, NACp = 9)
Horizontal velocity: 123 knots at 45 degrees (True Track)
Vertical velocity: 64 FPM climb
Emergency/Priority Code: none
Emitter Category: Light
Tail Number: N825V

Table 12 - Traffic Report Example

Byte # - Field	Value	Byte # - Field	Value
1 - Message ID	0x14	15 - hh	0x07
2 - st	0x00	16 - hv	0xB0
3 - aa	0xAB	17 - vv	0x01
4 - aa	0x45	18 - tt	0x20
5 - aa	0x49	19 - ee	0x01
6 - ll	0x1F	20 - cc	0x4E
7 - ll	0xEF	21 - cc	0x38
8 - ll	0x15	22 - cc	0x32
9 - nn	0xA8	23 - cc	0x35
10 - nn	0x89	24 - cc	0x56
11 - nn	0x78	25 - cc	0x20
12 - dd	0x0F	26 - cc	0x20
13 - dm	0x09	27 - cc	0x20
14 - ia	0xA9	28 - px	0x00

3.6. PASS-THROUGH REPORTS

When the pass-through interface is in use, the GDL 90 will output the received ADS-B messages as-is without further processing. Targets are selected for output based on proximity to the ownship position, and the amount of data interface bandwidth available. No traffic alerting service is provided when this interface is in use. No report extrapolation or coasting is performed.

There are two Pass-Through report messages; one for the Basic UAT message (see Table 13), and one for the Long UAT message (see Table 14).

See §3.3.1 for the format of the Time of Reception field.

Table 13 - Basic UAT Report (Output)

Byte #	Name	Size	Value
1	Message ID	1	30_{10} = Basic Report
2-4	Time of Reception	3	24-bit binary fraction Resolution = 80 nsec
5-22	Basic Payload	18	(see text)
	Total Length	22	

The format of the 18 bytes of Basic Payload is specified in RTCA/DO-282, Section 2.2.

Table 14 - Long UAT Report (Output)

Byte #	Name	Size	Value
1	Message ID	1	31_{10} = Long Report
2-4	Time of Reception	3	24-bit binary fraction Resolution = 80 nsec
5-38	Long Payload	34	(see text)
	Total Length	38	

The format of the 34 bytes of Long Payload is specified in RTCA/DO-282, Section 2.2.

3.7. HEIGHT ABOVE TERRAIN

The GDL 90 can use the Height Above Terrain information from other on-board equipment that supports terrain awareness, in order to provide reduced CSA sensitivity at low altitudes. The Display can provide the current Height Above Terrain to the GDL 90 using this message. Alternatively, the GDL 90 can use an ARINC 429 format Radio Altitude (label 164) for this purpose.

If Height Above Terrain from one of these sources is not provided to the GDL 90, CSA will not be able to use the lower sensitivity levels, which can result in an increased occurrence of nuisance traffic alerts.

Table 15 - Height Above Terrain Message (Input)

Byte #	Name	Size	Value
1	Message ID	1	9_{10} = HAT Message
2-3	Height Above Terrain	2	Height above terrain Resolution: 1 foot
	Total Length	3	

Height Above Terrain is encoded as a 16-bit signed value, with a resolution of 1 foot. The data is transmitted most significant byte first.

Example:

If Byte 2 is 0x01, and Byte 3 is 0x00, this represents a Height Above Terrain of 256 feet.

Special Value: The value 0x8000 indicates that the Height Above Terrain data is invalid.

3.8. Ownship Geometric Altitude Message

SW Mod C: When configured for either the Traffic Alert or Pass-through interfaces, the GDL 90 will output an Ownship Geometric Altitude message once per second, when geometric altitude is available. See Table 16 for the message format.

Table 16 - Ownship Geo Altitude Message (Output)

Byte #	Name	Size	Value
1	Message ID	1	11_{10} = Ownship Geo Alt
2 - 3	Ownship Geo Altitude	2	"dd dd" Signed altitude in 5 ft. resolution (see text)
4-5	Vertical Metrics	2	- Vertical Warning indicator - Vertical Figure of Merit, in meters (see text)
	Total Length	5	

The Ownship Geometric Altitude message is output by the GDL 90 only when the ownship GPS altitude is available.

The Geo Altitude field is a 16-bit signed integer that represents the geometric altitude (height above WGS-84 ellipsoid), encoded using 5-foot resolution, as follows:

Geo Altitude (ft) = "dddd" * 5

Byte 2 is the most-significant byte.

Geo Altitude Examples:

-1,000 feet	0xFF38
0 feet	0x0000
+1000 feet	0x00C8

The Vertical Metrics field contains a 1-bit value for the Vertical Warning indicator, and a 15-bit unsigned integer that represents the Vertical Figure of Merit in meters. Byte 4 is the most-significant byte.

The most significant bit of Byte 4 is the Vertical Warning indication. The bit is SET whenever a position alarm is present, or if fault detection is not available.

The remaining 15 bits represent the Vertical Figure of Merit in meters. Two of the values are reserved to indicate special conditions:

Value 0x7FFF is reserved to indicate that VFOM is not available.

Value 0x7FFE is reserved to indicate that VFOM is available and is >= 32766 meters.

Examples of Vertical Metrics values:

Vertical Warning and VFOM not available:	0xFFFF
No Vertical Warning, VFOM = 40,000 meters	0x7FFE
No Vertical Warning, VFOM = 10 meters	0x000A
Vertical Warning, VFOM = 50 meters	0x8032

4. Uplink Payload Format

This section defines the format of the Uplink Message payload.

Note: The following material is adopted from the SF21 East Coast project guidance document draft.

4.1. UPLINK MESSAGE

The UAT Uplink message is a general-purpose mechanism for the uplink of data services. Each Uplink message contains a 432-byte payload field. The payload is composed of an eight-byte UAT-Specific Header, followed by 424 bytes of Application Data. The Application Data field is further composed of one or more Information Frames (I-Frames). The overall composition of the Uplink message is shown in Figure 3.

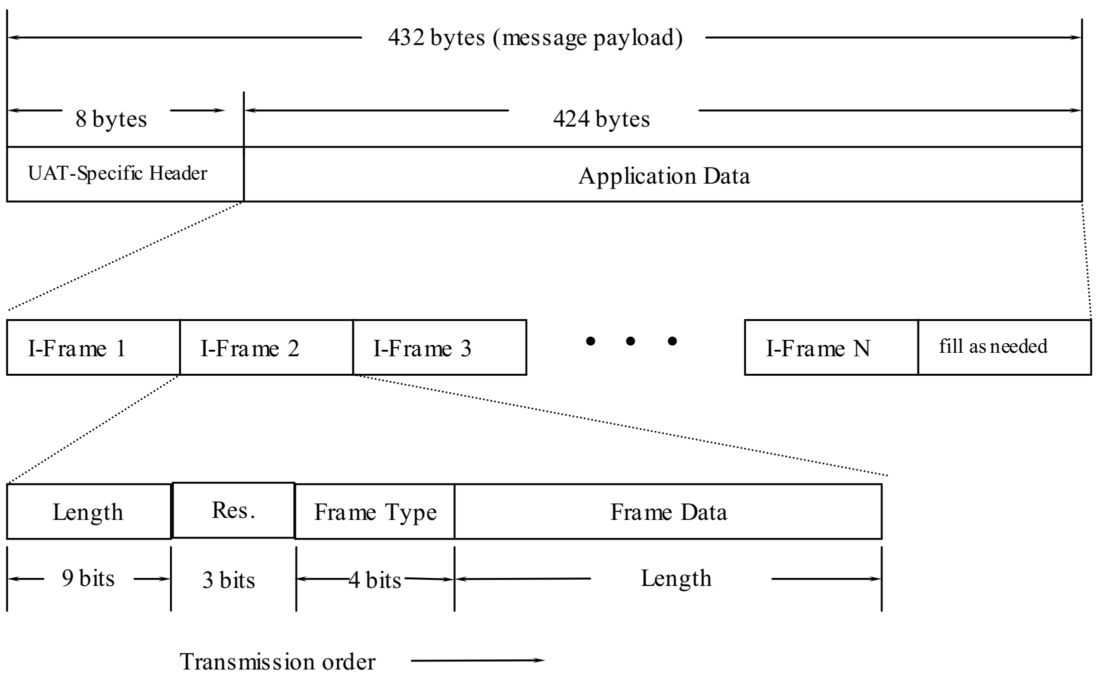

Figure 3 - Composition of the Ground Uplink Message Payload

4.1.1. UAT-Specific Header

The UAT-Specific Header is an 8-byte field that contains information on the location of the broadcasting ground station, the time slot used to send the present message, validity flags for position, time, and application data, and other fields as described in Section 2.2.3.2.2 of RTCA/DO-282.

4.1.2. Application Data

The Application Data is a fixed-length field of 424 bytes. The Application Data consists of Information Frames, and always consists of an integral number of bytes. Any remaining unused portion of the field is zero-filled (i.e., all bits set to ZERO).

> ***Note**: When processed by the I-Frame parsing logic, the zero-fill portion will appear as a Frame Length of zero bytes, or as an incomplete frame (if less than 2 bytes remain). Either condition indicates that that the Application Data contains no additional I-Frames.*

4.2. INFORMATION FRAMES

Each Information Frame consists of 'N' bytes, comprising four fields formatted as shown in Table 17.

Table 17 - I-Frame Structure

<table>
<tr><th>Byte #</th><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td>1</td><td colspan="8">Length</td></tr>
<tr><td>2</td><td>LSB</td><td colspan="3">Reserved</td><td colspan="4">Frame Type</td></tr>
<tr><td>3
-
N</td><td colspan="8">Frame Data</td></tr>
</table>

Note: Byte numbers in this table are relative to the beginning of the current Information Frame.

4.2.1. Length Field

The Length field (Byte 1 bit 7 through Byte 2 bit 7) is a 9-bit field that contains the length of the Frame Data field in bytes. Values range from 0 through 422 (decimal). The Length value is always equal to 'N-2'. If the Length value is zero, this indicates that there are no additional I-Frames in this message.

4.2.2. Reserved Field

The Reserved field (Byte 2 bits 6..4) is a 3-bit field that is reserved for future use, and will be set to ALL ZEROS.

4.2.3. Frame Type Field

The Frame Type field (Byte 2 bits 3..0) is a 4-bit field that contains the indication for the format of the Frame Data field. The Frame Types are defined in Table 18.

Table 18 - Frame Types

MSB **Value** (binary) LSB	**Frame Data Format**
0000	FIS-B APDU
0001 - 1110	Reserved for future use
1111	Reserved for Developmental use

When the Frame Type is the binary value "0 0 0 0", the Frame Data contains FIS-B data packaged as an Application Protocol Data Unit (APDU) as described in Section 3.6, and Appendix D of RTCA/DO-267.

Fourteen reserved values remain for future use.

When the Frame Type is the binary value "1 1 1 1", the Frame Data contains an Uplink message whose content is intended for developmental or experimental use, and should be processed as appropriate by those participating in those efforts.

4.2.4. Frame Data Field

The Frame Data field conveys the basic units of uplink application data. For FIS-B this data unit is known as the Application Protocol Data Unit (APDU) as defined in §4.3.

4.3. FIS-B PRODUCT ENCODING (APDUS)

Each APDU is comprised of an APDU Header followed by the APDU Payload.

4.3.1. APDU Header

The APDU header format is described in Appendix D of the RTCA/DO-267 (FIS-B MASPS) with one variation as described below.

The UAT APDU header does not include the 16-bit FIS-B APDU ID field defined in the FIS-B MASPS (i.e. as a fixed two byte field of 0xFF and 0xFE). Since UAT FIS-B APDUs are fully identified by the Frame Type field (see §4.2.3), inclusion of these two APDU ID bytes in the UAT APDU header is unnecessary, and they are omitted.

4.3.2. APDU Payload

The FAA Broadcast Services ground system presently encodes FIS-B data products for uplink using only *independent* APDUs as described in RTCA/DO-267. Each APDU stands alone in that each individual APDU received results in some data that can be rendered on the cockpit display; there is no dependence on the APDUs that precede or succeed it. In the event that future FIS-B products require an APDU longer than 422 bytes, then the APDU segmentation scheme described in RTCA/DO-267 may be used.

APDUs will carry products that are registered in the FAA's FIS-B product registry. This registry is maintained by the Weather Processor and Sensors Group (ACB-630) at the FAA's William J. Hughes Technical Center. The registry can be accessed at http://fpr.tc.faa.gov.

4.4. FIS-B Products

4.4.1. Textual METAR and TAF Products

The Textual METAR and TAF products use the format identified in the FIS-B product registry by the name "Generic Textual Data Product - Type 2 (DLAC)" and the 11-bit Product ID of "413_{10}". Details on the encoding of the text records are found in the FAA's FIS-B product registry (http://fpr.tc.faa.gov).

4.4.2. NEXRAD Graphic Product

The NEXRAD Graphic product is identified in the FIS-B product registry by the name "Global Block Representation – NEXRAD, Type 4 – 8 Level" and the 11 bit Product ID of "63_{10}". Details on the encoding of the text records are found in the FAA's FIS-B product registry (http://fpr.tc.faa.gov).

4.5. Future Products

The FAA UAT base station deployment plan will accommodate additional Uplink products. FAA will announce the availability of new products when they are ready for operational use. New products will be described in the FIS-B product registry.

5. FIS-B Product APDU Definition

The following information is taken from the data submitted for inclusion in the FIS-B Product Registry, and is provided as guidance until the registry is updated. In case of discrepancies between this document and the FIS-B Product Registry, the Registry takes precedence.

As additional FIS-B products are made available by the ground stations, full specifications will be disclosed through the FIS-B Product Registry. Updates to this document will not be required, and since the GDL 90 acts as a pass-through device for FIS-B Products, no updates to GDL 90 application software will be necessary.

<u>MFD Recommendation</u>: Display vendors may wish to consult RTCA/DO-267A for guidance on presentation of FIS-B products to the flight crew.

5.1. TYPE 4 NEXRAD PRECIPITATION IMAGE – GLOBAL BLOCK REPRESENTATION

5.1.1. Definition

This description provides the format for encoding NEXRAD graphic products using the Global Block Representation format described in Section D.2.3.5 of RTCA DO-267A (FIS-B MASPS).

5.1.2. Assumptions

The receiving system can assume that when this product is received from multiple ground stations offering overlapping coverage, the areas of overlap will be assured to register and can be simply merged on the cockpit display.

5.1.3. APDU Payload Format

5.1.3.1 APDU HEADER

The format of the APDU header used for this product is shown in Table 19. It follows the APDU Header Format as outlined in Appendix D of RTCA DO-267 with none of the optional fields used for this product; specifically, no Product Descriptor options and no APDU segmentation are used. The Product ID is "63"$_{10}$.

The last four zeros show the pad that is required to round out the APDU header to end on a byte boundary. The time field encoded in the APDU header is the time of product creation.

Table 19 - APDU Header - NEXRAD Graphics

<table>
<tr><td></td><td colspan="32">← APDU Header (32 bits) →</td></tr>
<tr><td>APDU ID</td><td>A f</td><td>G f</td><td>P F</td><td colspan="11">Product ID (11 bits)</td><td>S f</td><td colspan="2">T opt</td><td colspan="5">Hours (5 bits)</td><td colspan="6">Minutes (6 bits)</td><td colspan="4"></td></tr>
<tr><td>(See Note 1)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

Transmission order →

Note:

1) *The FIS-B APDU-ID is not transmitted in the FAA UAT FIS-B network. The length of the UAT APDU header is 32 bits, rather than 48 bits as defined in the FIS-B MASPS.*

2) *While this product employs the minimal APDU header format shown above, avionics designed for operation on the FAA's network should not preclude the ability to parse APDUs with any of the optional fields invoked. This will ensure any future products that may employ these optional fields can be processed.*

5.1.3.2 PAYLOAD

The Global Block Representation geo references individual "bins" of the NEXRAD image to latitude and longitude rather than on a projection requiring a point of tangency. The encoded intensity levels for the individual "bins" map into "dBz" reflectivity levels as shown in Table 20.

Table 20 - Intensity Encoding of NEXRAD Composite Reflectivity Product

Intensity Encoded Value	dBz Reflectivity Range	Weather Condition
0	dBz < 5	
1	5 ≤ dBz ≤ 20	
2	20 ≤ dBz ≤ 30	VIP 1
3	30 ≤ dBz ≤ 40	VIP 2
4	40 ≤ dBz ≤ 45	VIP 3
5	45 ≤ dBz ≤ 50	VIP 4
6	50 ≤ dBz ≤ 55	VIP 5
7	55 ≤dBz	VIP 6

Note:

1) *The color rendering on cockpit displays of the Intensity Encoded Values 2(two) through 7 (seven) should follow the Color Philosophy for the associated Weather Condition as described in Section 3.8.2 (Table 3-2) of RTCA DO-267A (FIS-B MASPS).*
2) *The Intensity Encoded Values 0 (zero) and 1 (one) are considered Background and should be color rendered accordingly.*

The Global Block Representation itself is defined in detail in Section D.2.3.5 of RTCA/DO-267A, and is not replicated here due to copyright considerations.

5.1.4. FIS-B Graphical Example

This section presents hexadecimal data for two sample 424-byte Application Data fields. These fields convey a graphical NEXRAD image for an area of northern Oregon. The graphical image contains a test pattern that depicts three colored elliptical areas that roughly resemble precipitation cells, surrounded by a region that contains no precipitation.

The sample Application Data fields contain a total of 19 APDUs; nine of the APDUs contain run-length encoded blocks, and 10 APDUs contain Empty Element blocks. Three APDUs make up each ellipse (a top, middle, and bottom stripe).

Step-by-step decoding process:

The first two bytes (0x1300) are the I-Frame Length (Length = 38) and Frame Type (Type 0, FIS-B APDU) for the first APDU.

The following 4 bytes (0x00 0xFC 0x00 0x00) are the APDU Header (Product ID=63_{10}, Time = 00 hr 00 min). Note that the APDU Header Time for a NEXRAD Graphic product would typically contain the time of product creation, but does not in this example.

The following three bytes (0x84 0xA5 0x70) carry the Block Reference Indicator, as shown in RTCA/DO-267A, Appendix D.2.3.5.2.2, Figure 10. The Element Identifier is SET, indicating that this APDU describes a run-length encoded block, and the Block Reference Number is 0x4A570 in the North hemisphere. This block occupies a region from 123º 12' to 122º 24' West longitude, and from 45º 04' to 45º 08' North latitude.

Each of the remaining bytes of the APDU encode the value of each of the 128 bins that comprise this block (as 4 rows of 32 bins each). In each byte, the upper 5 bits represent the number of sequential bins (minus 1) that each have the intensity value given in the lower 3 bits. The next byte in the example data (0x30) indicates that the first 7 bins have Intensity value 0. The following byte (0x89) indicates that the next 18 bins have Intensity value 1. The following byte (0x50) indicates that the next 11 bins (the last 7 of the first row, plus the first 4 of the following row) have Intensity value 0.

Parsing the entire first APDU will yield the following Intensity values shown in Table 21 for this block (blank cells represent Intensity = 0).

Table 21 - Sample Block Decoding

							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
				1	1	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	2	2	2	1	1					
		1	1	1	2	2	3	3	3	3	3	5	5	5	5	5	5	5	5	5	3	3	3	3	2	2	1	1			
	1	1	2	2	3	3	3	3	4	4	5	5	5	5	6	7	6	5	5	5	5	4	3	3	3	3	2	2	1		

The remaining 8 run-length encoded APDUs are processed in like manner.

The 10 APDUs that encode Empty Element blocks serve to map the entire rectangular region from 124º 00' to 120º 00' West longitude, and from 44º 56' to 45º 32' North latitude (other than the three precipitation ellipses) to the Intensity = 0 value. Outside of this region, the MFD should show that no data is available.

Sample Application Data Field 1:

130000FC000084A570308950111A53120930110A23451B0A0918090A1B0C1D0607061D041
B0A0108208000FC000084A3AE00090A1314150617061D04130A01080112131C0D06270615
140B0A01000112131C0D06270615140B0A010000090A1314150617061D04130A0108148000
FC000084A1EC00090A1B0C1D0607061D041B0A010808110A23451B0A091018111A531209
20308930130000FC000084AAB7308950111A53120930110A23451B0A0918090A1B0C1D060
7061D041B0A0108208000FC000084A8F500090A1314150617061D04130A01080112131C0D
06270615140B0A01000112131C0D06270615140B0A010000090A1314150617061D04130A01
08148000FC000084A73300090A1B0C1D0607061D041B0A010808110A23451B0A091018111
A5312092030893013000OFC000084AFFD308950111A53120930110A23451B0A0918090A1B
0C1D0607061D041B0A010800000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000

Sample Application Data Field 2:

208000FC000084AE3B00090A1314150617061D04130A01080112131C0D06270615140B0A0
1000112131C0D06270615140B0A010000090A1314150617061D04130A0108148000FC00008
4AC7900090A1B0C1D0607061D041B0A010808110A23451B0A091018111A5312092030893
0040000FC000004B1BDF0040000FC000004AFFBD0040000FC000004AE39D0040000FC000
004AC77D0040000FC000004AAB5D0040000FC000004A8F3D0040000FC000004A731D004
0000FC000004A56FE0040000FC000004A3ADE0040000FC000004A1EBE0000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000
00000000000000000000000

5.2. GENERIC TEXTUAL DATA PRODUCT – TYPE 2 (DLAC)

5.2.1. Definition

This description is based on the Generic Text Data Product Type 2, except that the DLAC 6-bit alphabet will be used. This Generic Text Data Product is represented as strings of characters in a format that is independent of the type of text product itself. The advantage of the Generic Text product is that new types of text records following this format can be introduced without necessitating changes to the Display software.

5.2.2. APDU Payload Format

5.2.2.1 APDU HEADER

The format of the APDU header used for this product is shown in Table 22. It follows the APDU Header Format as outlined in Appendix D of RTCA DO-267 with none of the optional fields used for this product; specifically, no Product Descriptor options and no APDU segmentation are used. The Product ID is "413"$_{10}$.

The last four zeros show the pad that is required to round out the APDU header to end on a byte boundary. For this product, the time field encoded in the APDU header has no meaning. Each text record contains a time field that should be used to indicate product age.

Table 22 - APDU Header - Generic Text

← APDU Header (32 bits) →									
APDU ID	Product Descriptor (14 bits)					Header Time (13 bits)			Pad (4 bits)
	A f	G f	P f	Product ID (11 bits)	S f	T opt	Hours (5 bits)	Minutes (6 bits)	
(See Note 1)	0	0	0	0 0 1 1 0 0 1 1 1 0 1	0	0 0			0 0 0 0

Transmission order →

Note:

1) *The FIS-B APDU-ID is not transmitted in the FAA UAT FIS-B network. The length of the UAT APDU header is 32 bits, rather than 48 bits as defined in the FIS-B MASPS.*

2) *While this product employs the minimal APDU header format shown above, avionics designed for operation on the FAA's network should not preclude the ability to parse APDUs with any of the optional fields invoked. This will ensure any future products that may employ these optional fields can be processed*

3) *The Hours and Minutes fields in the APDU Header have no meaning for this product, as a Time field is included in each text record.*

5.2.2.2 PAYLOAD

General Requirements

1. All Text is composed of the DLAC 6 bit character set encoded per Appendix K of RTCA DO-267A (FIS-B MASPS).
2. Within each character the most significant bit is transmitted first. The most significant bit of character n+1 follows immediately after the least significant bit of character n.
3. The APDU will be composed of one or more whole, concatenated text records.
4. One text record will not span more than one APDU payload.
5. The length of a text record will have a maximum size of 418 bytes.

Note: An artificial limit smaller than 418 bytes may be imposed to eliminate ongoing remarks in the text message. The value would be chosen to meet two criteria:

1) the required information in the original report is faithfully preserved; and

2) the resulting size would allow several text messages to pack efficiently into each Ground Uplink message payload.

5.2.3. METAR / TAF Composition

Text records for METAR and TAF are composed as shown in the syntax below:

Record = <Type> <sp> <LocID> <sp> <Time> [SP|AM]<sp> <Text report> <RS><fill bits>

The syntax elements and rules for text record composition are shown in Table 23 below:

Table 23 - METAR/TAF Structure

Syntax Element	Description	Required/ Optional
`<>`	Denotes a text string	N/A
`[]`	Denotes an optional field	N/A
`sp`	Denotes a single space character (100000_2)	Required
`RS`	Denotes the record separator character (011101_2)	Required
`Type`	One or more characters not containing the <sp> or <RS>. Limited to “METAR” and “TAF” initially	Required
`LocID`	One or more characters that can not contain <sp> or <RS>, required. Recommended but not limited to standard location Identifiers (i.e., ILN, SDF)	Required
`Time`	One or more characters that can not contain <sp> or <RS>. Typically represents UTC date/time group (i.e., 012155Z), and it is used to convey the Product Age for the report.	Required
`SP or AM`	SP denotes special METAR (SPECI) as a subset of METAR, or AM denotes amendments (AMEND) as a subset of TAF.	Optional
`Text report`	One or more characters that cannot contain <RS>. This is the actual text of the WMO report that may be displayed exactly as received without additional formatting or interpretation.[1]	Required
`Fill bits`	0, 2, 4, or 6 bit positions set to ALL ZEROs as required to zero fill any unused bits in the last byte of the record.	Required for byte alignment

[1] METAR and TAF messages may contain the equals (‘=’) character to indicate a message delimiter, or the string “NIL=” to indicate a report that is missing or delayed. The “NIL=” string may replace either the LocID or Time fields. The display processor should be capable of gracefully handling these conditions. See also US National Weather Service Instruction 10-813, Feb 7, 2005, "Terminal Aerodrome Forecasts.

5.2.4. FIS-B Text Example

The following hexadecimal data represents a sample 424-byte Application Data field. This sample message conveys textual TAF reports for several Oregon airports.

The sample Application Data field contains five APDUs. Each APDU conveys a single TAF report.

Step-by-step decoding process:

The first two bytes (0x2180) are the I-Frame Length (Length = 67) and Frame Type (Type 0, FIS-B APDU).

The following 4 bytes (0x06 0x74 0x41 0x90) are the APDU Header (Product ID=413, Time = 16 hr 25 min). Note that the APDU Header Time is unused for FIS-B Text messages, but is included here for illustration.

The remaining 63 bytes contain packed 6-bit DLAC characters that make up the text records for this report. Decoding the first 3 bytes (0x50 0x11 0xA0) yields the 4 DLAC values 20, 1, 6, and 32, which represent the letters 'T', 'A', 'F', <space>.

Continuing in this manner, the next 3 bytes represent the text "KSLE". The next 6 bytes represent the text " 260900Z". Therefore, the first three text fields of the first APDU of this Application Data Field are "TAF KSLE 260900Z". Since the text fields are always space-delimited, the third field is the date/time group for this TAF.

The remainder of the APDUs contain similar TAF reports for "KPDX", "KEUG", "KAST", and "KHIO". The body of the TAF text is identical for all 5 reports. The end of the Application Data is zero-filled to the fixed length of 424-bytes.

Sample Application Data Field (424 bytes):

2180067441905011a02d3305832db0e70c1a04d832d71cf1d60c38c30d8b5204364cd806157c36c
2008b3b1cb079c146370d30c205920b0ccb5204364cd8130d4cb5c3d79d2180067441905011a02d
0118832db0e70c1a04d832d71cf1d60c38c30d8b5204364cd806157c36c2008b3b1cb079c146370
d30c205920b0ccb5204364cd8130d4cb5c3d79d2180067441905011a02c5547832db0e70c1a04d8
32d71cf1d60c38c30d8b5204364cd806157c36c2008b3b1cb079c146370d30c205920b0ccb52043
64cd8130d4cb5c3d79d2180067441905011a02c14d4832db0e70c1a04d832d71cf1d60c38c30d8b
5204364cd806157c36c2008b3b1cb079c146370d30c205920b0ccb5204364cd8130d4cb5c3d79d2
180067441905011a02c824f832db0e70c1a04d832d71cf1d60c38c30d8b5204364cd806157c36c2
008b3b1cb079c146370d30c205920b0ccb5204364cd8130d4cb5c3d79d00000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000

6. Control Panel Interface

The GDL 90 receives control messages over the Control Panel interface (on the DB15 - P1 connector), using pin 12 (input to GDL 90) and pin 5 (ground). The interface uses an ASCII-text basis, with an ASCII-encoded hexadecimal checksum. The checksum is the algebraic sum of the message byte values. Messages are delimited with a carriage return character.

CAUTION

Equipment used to control the GDL 90 must be FAA-approved and certified under TSO-C154.

6.1. PHYSICAL INTERFACE

The Control Panel interface uses RS-232 signaling levels. The port is configured for the following characteristics:

Baud Rate: 1200 or 9600 baud (configurable)
Start Bits: 1
Data length: 8 bits
Stop Bits: 1
Parity: None
Flow Control: None

6.2. CONTROL MESSAGES

The following table summarizes the Control Panel messages that the GDL 90 receives.

Table 24 - Control Messages

Msg ID	Description	Notes	Ref
^CS	Call Sign	1 min interval or on change	6.2.1
^MD	Operation Mode Message	1 second interval (nominal)	6.2.2
^VC	VFR Code	1 min interval	6.2.3

6.2.1. Call Sign Message

The call sign message provides for a user selectable call sign.

Rate: Every 1 minute or when a change occurs

Message Length: 15 bytes

6.2.1.1 CALL SIGN FORMAT SPECIFICATION

Table 25 - Call Sign Message Format

Byte	Contents	Description
1	‘^’	ASCII ‘^’ (0x5E)
2	‘C’	ASCII ‘C’ (0x43)
3	‘S’	ASCII ‘S’ (0x53)
4	‘ ‘	ASCII space (0x20)
5-12	dddddddd	ASCII call sign (all 8 characters are mandatory, right pad with space)
13-14	dd	Checksum of bytes 1 through 12. In hex ASCII i.e. “FA”
15	‘\r’	ASCII carriage return (0x0D)

6.2.1.2 CALL SIGN MESSAGE EXAMPLES

^CS GARMIN 12   Call Sign is “GARMIN “ (includes two trailing spaces before checksum)

6.2.2. Mode Message

The mode message indicates the current operating mode. It includes the current mode, the Ident status, current Squawk code setting, and emergency code.

Rate: 1 sec (nominal)
Message Length: 17 bytes

6.2.2.1 MODE FORMAT SPECIFICATION

Table 26 - Mode Message Format

Byte	Contents	Description
1	'^'	ASCII '^' (0x5E)
2	'M'	ASCII 'M' (0x4D)
3	'D'	ASCII 'D' (0x44)
4	' '	ASCII space (0x20)
5	m	See Table 27 - Mode Field
6	', '	ASCII comma (0x2C)
7	i	See Table 28 - Ident Field
8	','	ASCII comma (0x2C)
9-12	dddd	ASCII Squawk code
13	e	See Table 29 - Emergency Field
14	h	Health bit in hex ASCII "1"
15-16	dd	Checksum of bytes 1 through 14. In hex ASCII i.e. "FA"
17	'\r'	ASCII carriage return (0x0D)

The field values are discussed in the following tables.

Table 27 - Mode Field

m	Definition	ASCII
O	Standby Mode	0x4F
A	Mode A	0x41
C	Mode C	0x43

Standby Mode turns the GDL 90 transmitter off, so that no ADS-B messages are transmitted. Mode A suppresses the transmission of pressure altitude in the ADS-B messages. Mode C is the normal operating mode, which includes pressure altitude.

Table 28 - Ident Field

i	Definition	ASCII
I	Ident Enabled	0x49
-	Ident is Inactive	0x2D

When IDENT is enabled, this causes the GDL 90 to include the IDENT indication in the transmitted ADS-B messages for the next 20 seconds.

Table 29 - Emergency Field

e	Definition	ASCII
0	None	0x0
1	General	0x1
2	Medical	0x2
3	Fuel	0x3
4	Com	0x4
5	Hijack	0x5
6	Downed	0x6

Any active emergency code is included in the GDL 90's transmitted ADS-B messages.

The Health indication is set to '1' by the control panel to indicate that it is operating normally.

6.2.2.2 MODE MESSAGE EXAMPLE

^MD A,I,23540120 Mode A, Ident active, Squawk 2354, No Emergency, Healthy

6.2.3. VFR Code Message

The VFR Code message informs the GDL 90 of the squawk code that is used to indicate the VFR operating condition. In the US NAS, this is the value “1200”.

6.2.3.1 INTERFACE SPECIFICATION

Rate: 1 minute
Message Length 11 bytes

6.2.3.2 VFR CODE FORMAT SPECIFICATION

Table 30 - VFR Code Message Format

Byte	Contents	Description
1	‘^’	ASCII ‘^’ (0x5E)
2	‘V’	ASCII ‘V’ (0x56)
3	‘C’	ASCII ‘C’ (0x43)
4	‘ ‘	ASCII space (0x20)
5-8	dddd	ASCII VFR Code ASCII characters
9-10	dd	Checksum of bytes 1 through 8. In hex ASCII i.e. “FA”
11	‘\r’	ASCII carriage return (0x0D)

6.2.3.3 VFR CODE MESSAGE EXAMPLES

^VC 1200DA VFR code is 1200

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